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THE OHIO STATE UNIVERSITY

Cognitive Engineering in Aerospace Applications

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Semi-Annual Progress Report
for the
NASA Cooperative Agreement NCC2-592

"Cognitive Engineering in Aerospace Applications"

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Project Overview

This report describes the progress that has been made with respect to the objectives and goals of the research that is being carried out in the Cognitive Systems Engineering Laboratory (CSEL) under a Cooperative Agreement with NASA Ames Research Center ('Cognitive Engineering in Aerospace Applications', NCC2-592, Principal Investigator: David D. Woods).

The major objective of this project is to expand the research base in Cognitive Engineering to be able to support the development and human-centered design of automated systems for aerospace applications.

This research project is in support of the Aviation Safety/Automation Research Plan and related NASA research goals in space applications.

Pilot-Automation Coordination on Advanced Automated Flight Decks

Under this Cooperative Agreement, an earlier series of studies of pilot-automation interaction on the B-737-300/400 identified as one of the major sources of problems deficiencies in pilots' awareness of the status and behavior of the automation. A thorough analysis of the nature of and reasons for the observed difficulties indicated that they are the result of an interaction between the different and not always complementary abilities, limitations, and strategies of both the human and the machine agent in the system.

Given that difficulties with pilot-automation interaction are determined in part by the nature of the automation, recent rapid developments in cockpit technology can be expected to change the nature of known problems or to create the opportunity for entirely new problems to occur. In other words, it is not clear that the results of our previous research on the B-737-300/400 can be generalized across all glass cockpit aircraft. Instead, it seems important to find out how recently developed cockpit systems alter the nature of problems experienced by pilots during training for and line operations of these newer aircraft.

To trace the impact of technology, we are carrying out a new series of comparative studies on the Airbus A-320, the latest and most advanced automated aircraft currently in operation. The automation on this aircraft can be characterized as involving a high level of authority and autonomy in combination with drastic changes in feedback that may reduce the observability of the system. The questions we are asking is whether this kind of automation creates new forms of errors and human-machine mismatches, what the nature of these problems is, and how they can be addressed through modifications of training and design.

To answer these questions, we are cooperating with Northwest Airlines, an airline that has many years of experience with the operation of the largest U.S. Airbus A-320 fleet. One of the first activities in our joint project was a survey of all NWA A-320 pilots to gather detailed information about their experiences with the training for and the operation of the A-320 automation. In combination with our own training observations at the airline in January 1994, the survey helped identify possible areas of improvement for the training program that were proposed to NWA during a briefing at the end of January 1994. In particular, it was pointed out that advanced aircraft like the A-320 require training aids and curricula that allow time for, provide pilots with the opportunity to and encourage them to actively explore their highly flexible and dynamic automation. For example, classroom instruction can be enhanced by including high-quality visual illustrations of the flow of indications that pilots can expect to see and need to monitor on their cockpit screens in different evolving situations. Computer-based instruction needs to be expanded as it is often too inflexible and only accepts one or few ways of carrying out a task when the actual system provides a large number of different acceptable strategies.

The survey also yielded design-related results concerning pilots' experiences with new forms of controls (e.g. sidestick, non-moving thrust levers), and it produced detailed reports of situations where pilots were surprised when the A-320 automation showed unexpected behavior or failed to carry out the expected activities. An analysis of these reports seems to suggest that gaps in the proficiency of the automation are one of the major reasons for a breakdown in coordination and a lack of mode awareness on this aircraft. Given the high degree of autonomy and authority that has been implemented in the automation on this aircraft, and given its ability to detect and recover from a large number of undesirable circumstances on its own, it is difficult to anticipate and deal with these gaps in its knowledge and capabilities. To test our assumptions, we are currently conducting the next step in this line of research, an experimental simulator study of pilot-automation communication and coordination on the Airbus A-320. The 1.5 hr scenario for this study consists of numerous probes and events that involve a high potential for autoflight-related surprises. Participants in this study are 20 experienced A-320 pilots who fly the scenario on NWA's full-flight simulator. We expect to finish the data collection for this experiment by the end of June.

In preparation for this study, Ms. Nadine Sarter was given the opportunity to complete NWA's A-320 training program in March and April 1994. This training not only supports her in her current work on the experimental study but also provided her with invaluable insight in to the process of exploring and adapting to a very 'strong and silent' agent in the cockpit. For our previous study on pilot-automation interaction on the B-737-300/400, Ms. Sarter had also been able to complete the autoflight-related elements of training for this less advanced aircraft at a different airline. This combination of training experiences helps us understand the nature of and reasons for problems experienced by pilots transitioning to a 'glass cockpit' aircraft. It allows us to make progress in defining what makes for an effective approach to training for different automated aircraft.

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Recent Publications and Presentations

Sarter, N.B. and Woods, D.D. (1994). Pilot Interaction with Cockpit Automation II: An Experimental Study of Pilots' Model and Awareness of the Flight Management System. The International Journal of Aviation Psychology, 4(1), pp. 1-28.

Sarter. N.B. and Woods, D.D. (1994). Decomposing Automation: Authority, Autonomy, Observability, and Perceived Animacy. In Proceedings of the First Automation Technology and Human Performance Conference. Washington, D.C., April 7-9, 1994.

Sarter, N.B. and Woods, D.D. (1994). Training for Advanced Automated Aircraft - The Need for Active Exploration. Briefing to Northwest Airlines Representatives, Northwest Airlines, Minneapolis, January 28.

Sarter, N.B. (in preparation). Cockpit Automation. In Parasuraman, R and Mouloua, M. (Eds.), Automation and Human Performance: Theory and Applications. LEA, Series on Human Factors in Transportation.

Woods, D.D., Billings, C.E., and Sarter, N.B. (1994). The Price of Flexibility - Air-Ground and Ground-Ground Coordination in Critical Dynamic Situations. Presentation at the meeting of the ATA DataLink Human Factors Team at the FAA in Washington, D.C., January 19-21.

Woods, D.D., Johannesen, L.J., Cook, R.I., Sarter, N.B. (in press). Behind Human Error: Cognitive Systems, Computers, and Hindsight. Crew Systems Ergonomic Information and Analysis Center, Dayton, OH. State of the Art Report.

Woods, D.D. (1994). Automation: Apparent Simplicity, Real Complexity. Conference Keynote Address at the First Automation Technology and Human Performance Conference. Washington, D.C., April 7-9, 1994.

Woods, D.D. (in preparation). Cognitive Engineering in Automated Systems. In Parasuraman, R. and Mouloua, M. (Eds.), Automation and Human Performance: Theory and Applications. LEA, Series on Human Factors in Transportation.